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Brunel et al.

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(54) **MOTOR VEHICLE EXHAUST LINE**

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USPC 422/168, 172
See application file for complete search history.

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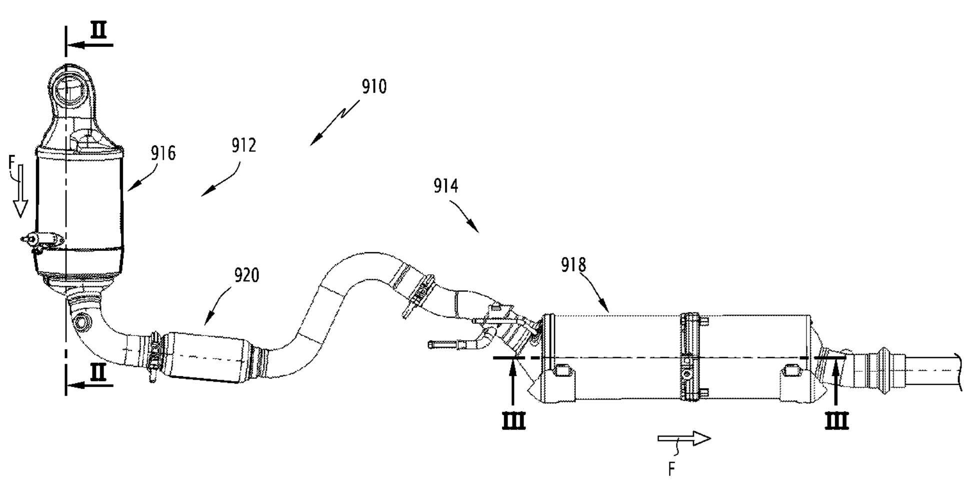
(57) **ABSTRACT**

A motor vehicle exhaust line includes a hot pipe, and a cold pipe for exhaust gases. A mechanical decoupling element connects a downstream end of the hot pipe to an upstream end of the cold pipe. The exhaust line also includes a nitrogen oxide treatment device and an injector intended to reinject a reagent into, or to produce a reagent in the exhaust line upstream of the nitrogen oxide treatment device. The exhaust line includes a mixer intended to mix the exhaust gases and the reagent injected or produced by the injector. The mixer is positioned upstream of the nitrogen oxide treatment device. The nitrogen oxide treatment device is disposed in the cold pipe downstream of the mechanical decoupling element. The injector and the mixer form an assembly connected directly to the mechanical decoupling element.

24 Claims, 14 Drawing Sheets



(51) **Int. Cl.**

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B01F 5/00	(2006.01)
B01F 5/04	(2006.01)
B01F 5/06	(2006.01)
F01N 3/20	(2006.01)
F01N 3/28	(2006.01)
F01N 13/18	(2010.01)

(52) **U.S. Cl.**
CPC ***F01N 13/1811*** (2013.01); *B01F 2215/0431* (2013.01); *F01N 2240/20* (2013.01); *F01N 2610/02* (2013.01); *F01N 2610/1453* (2013.01)

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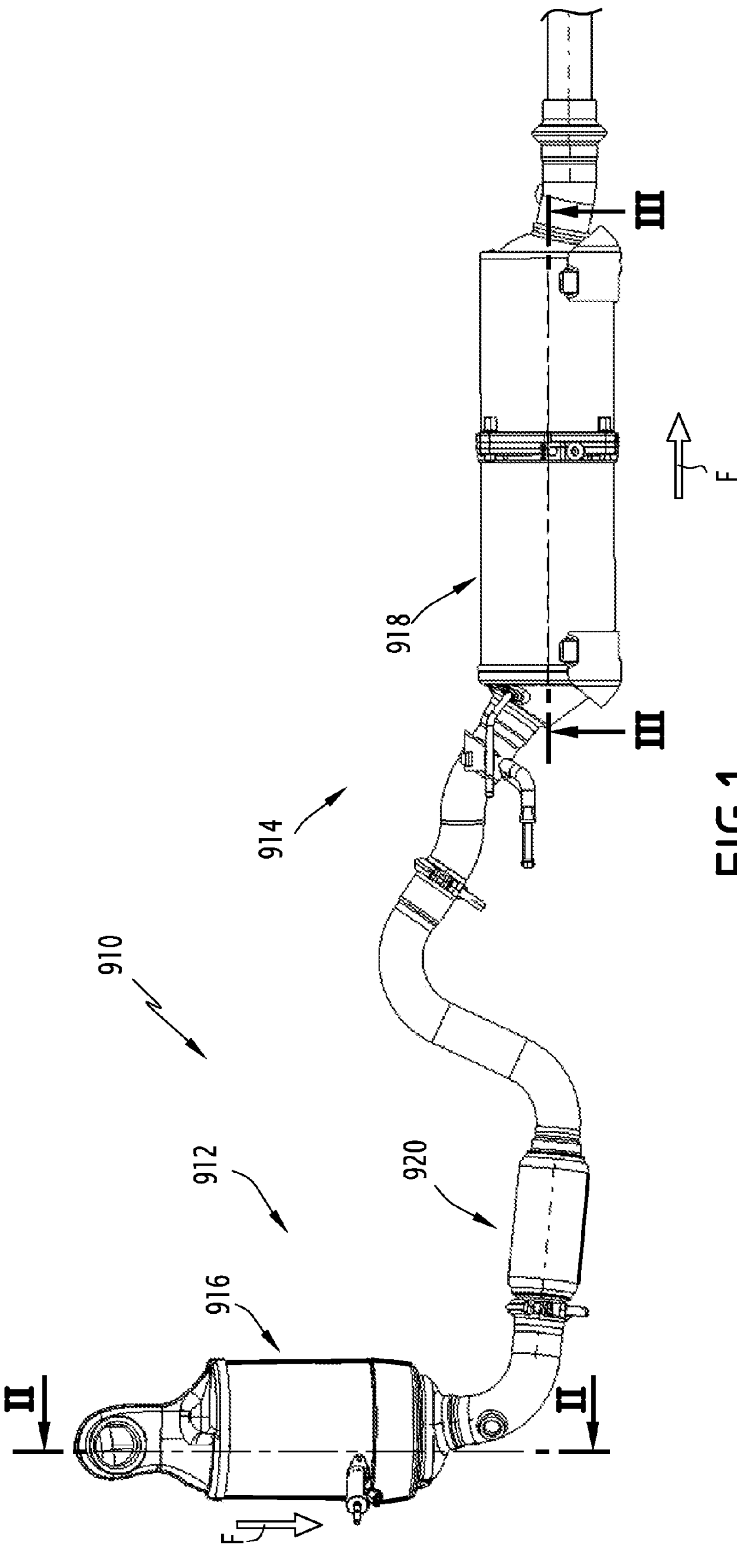


FIG.1

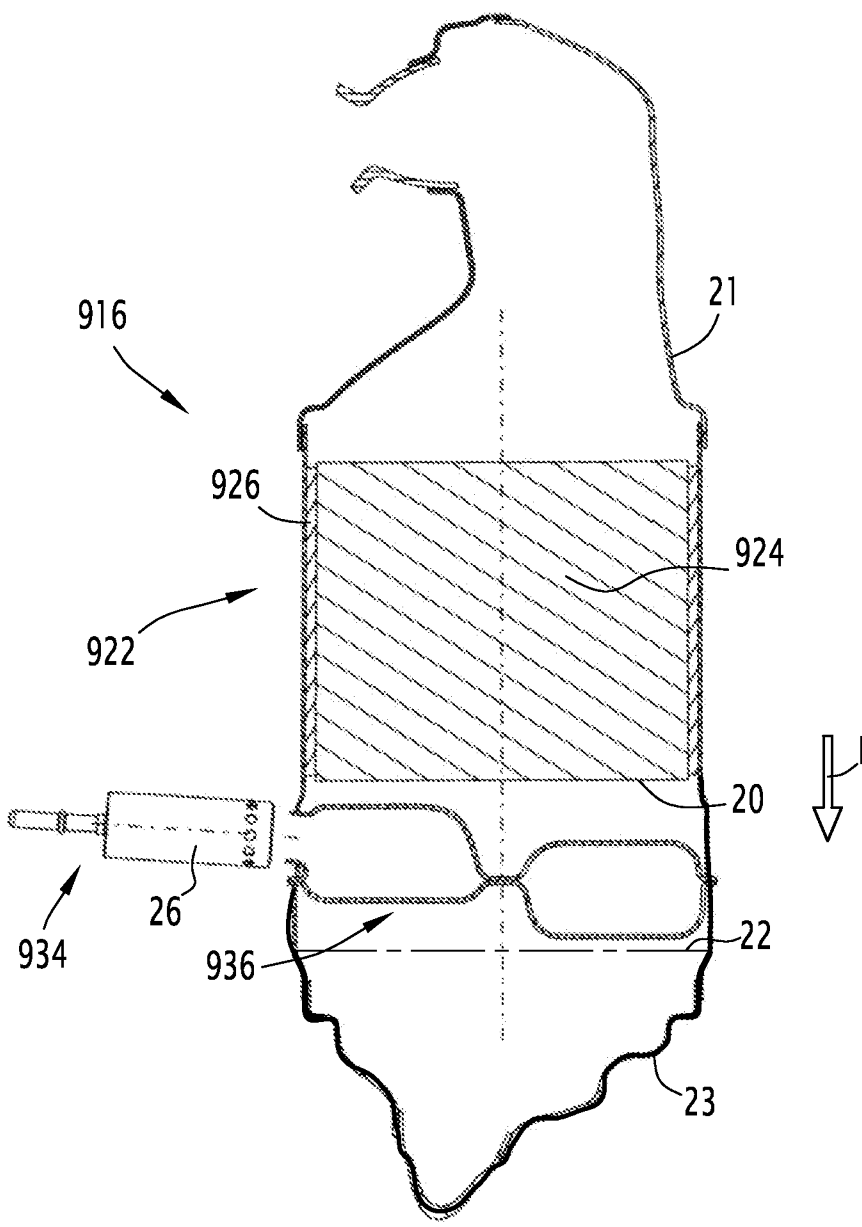


FIG.2

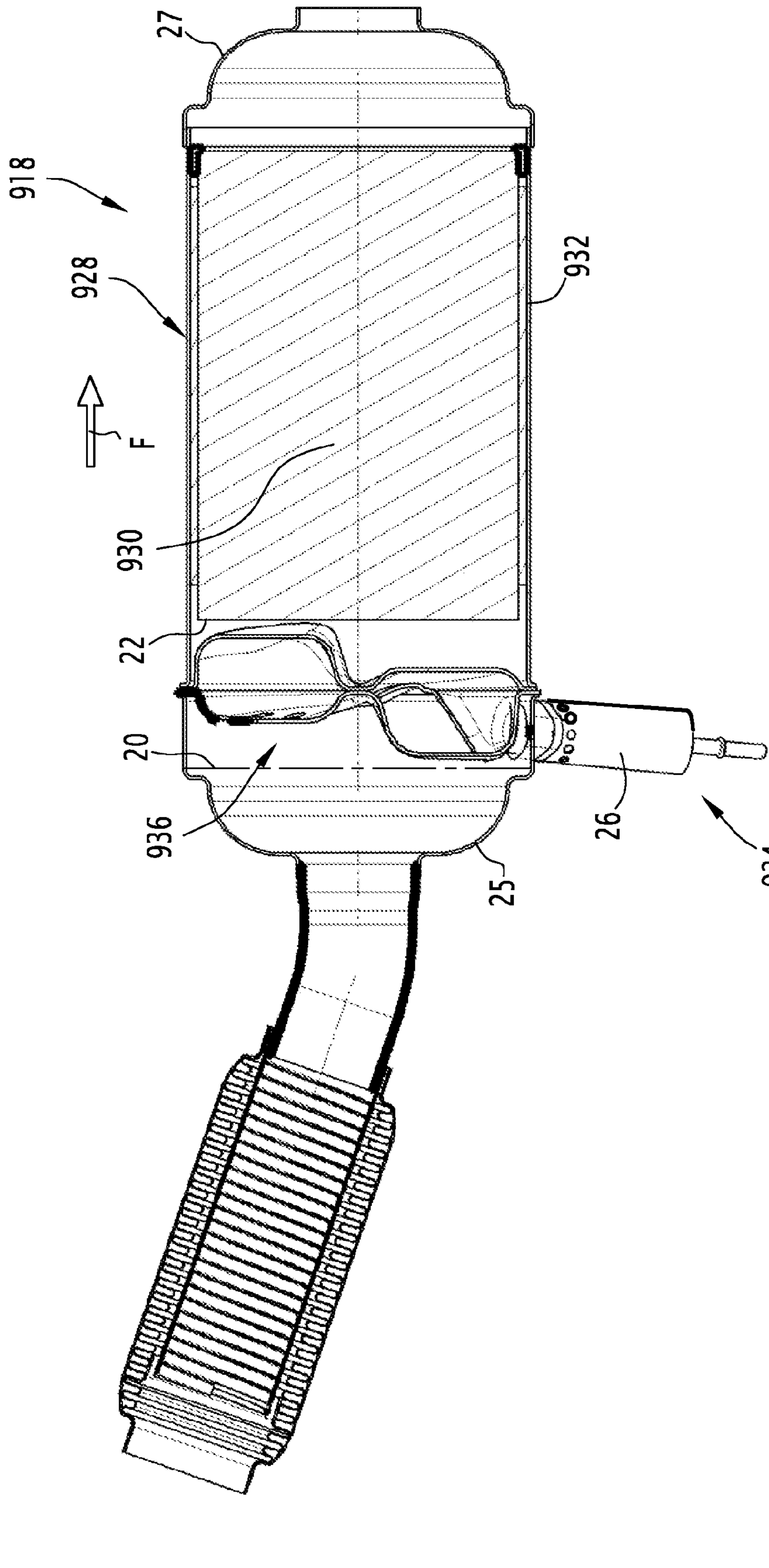


FIG.3

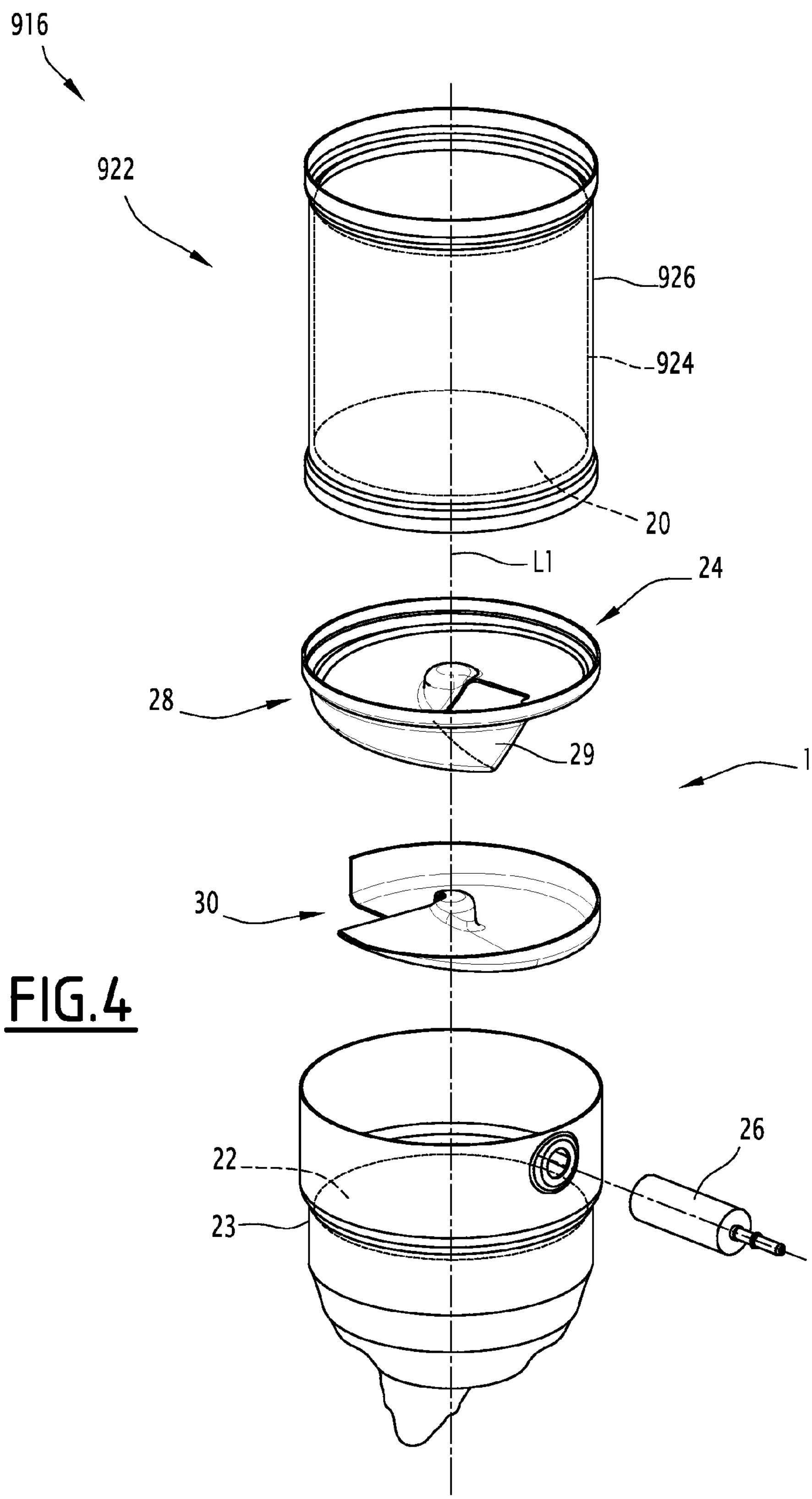


FIG.4

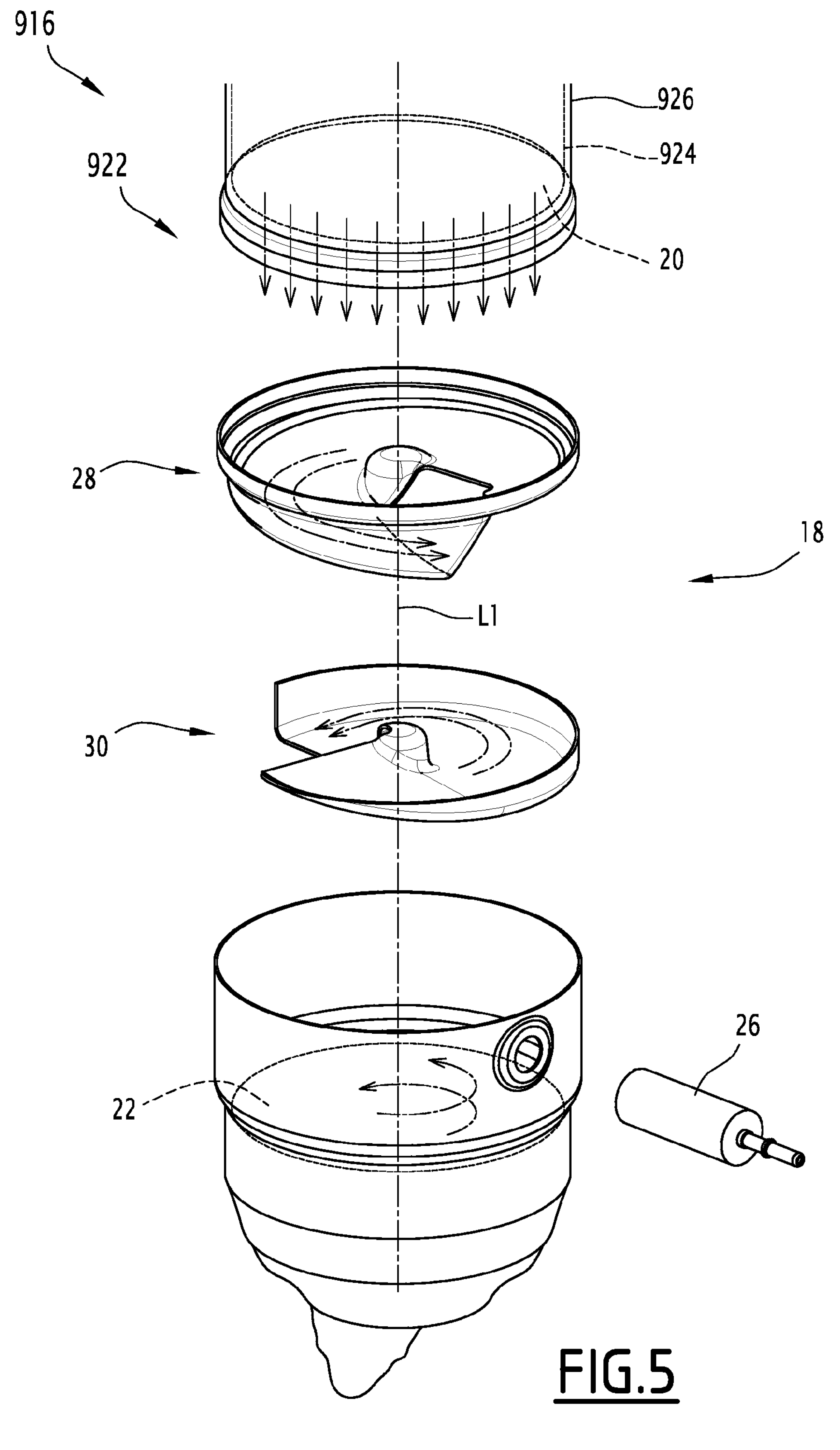


FIG.5

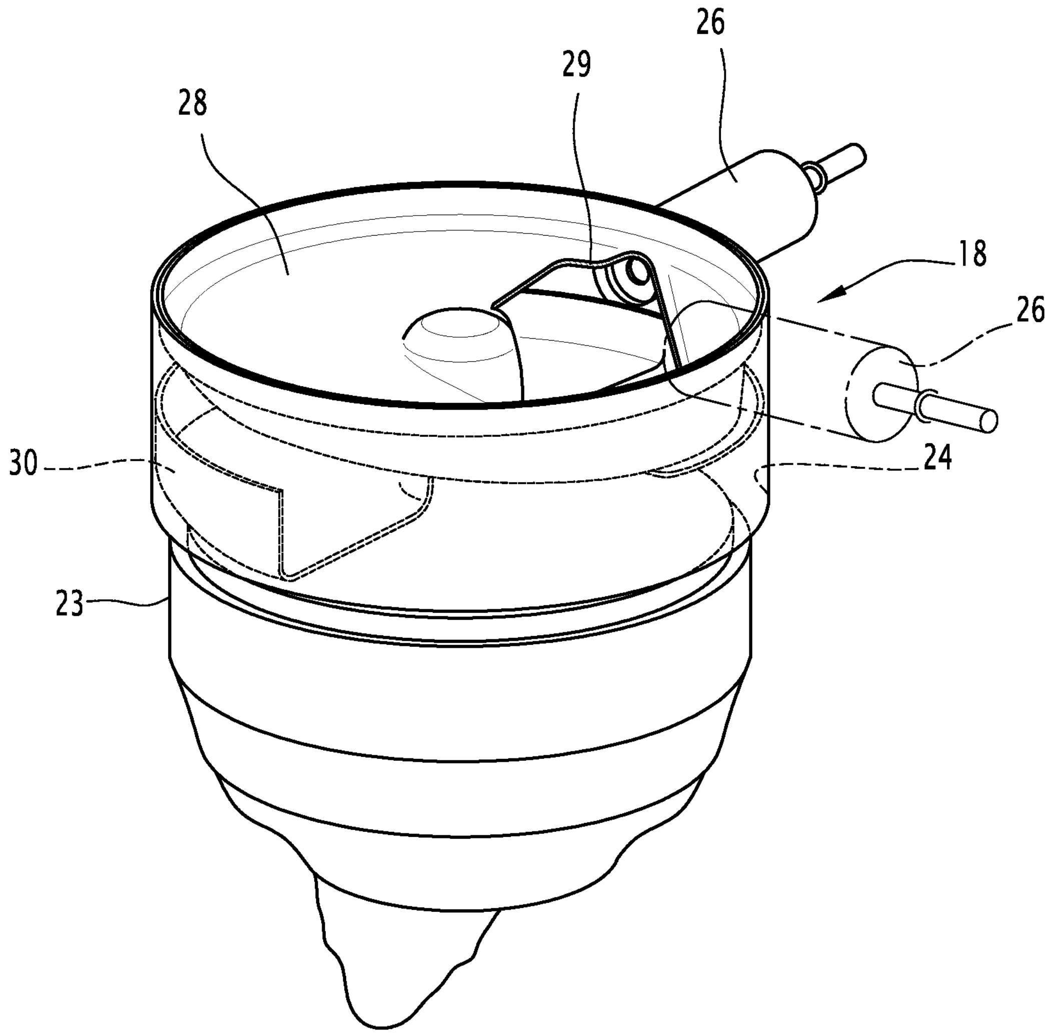


FIG.6

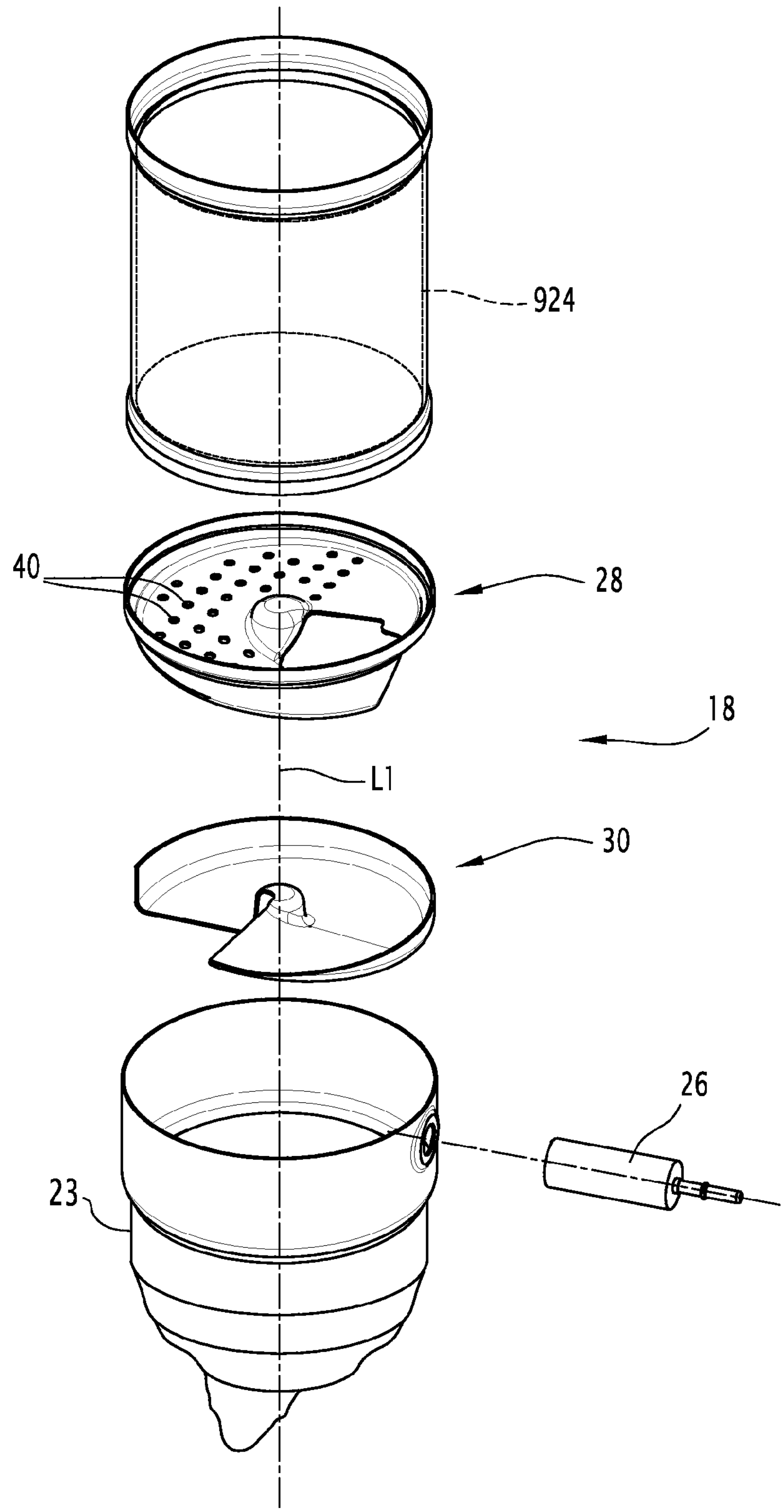


FIG.7

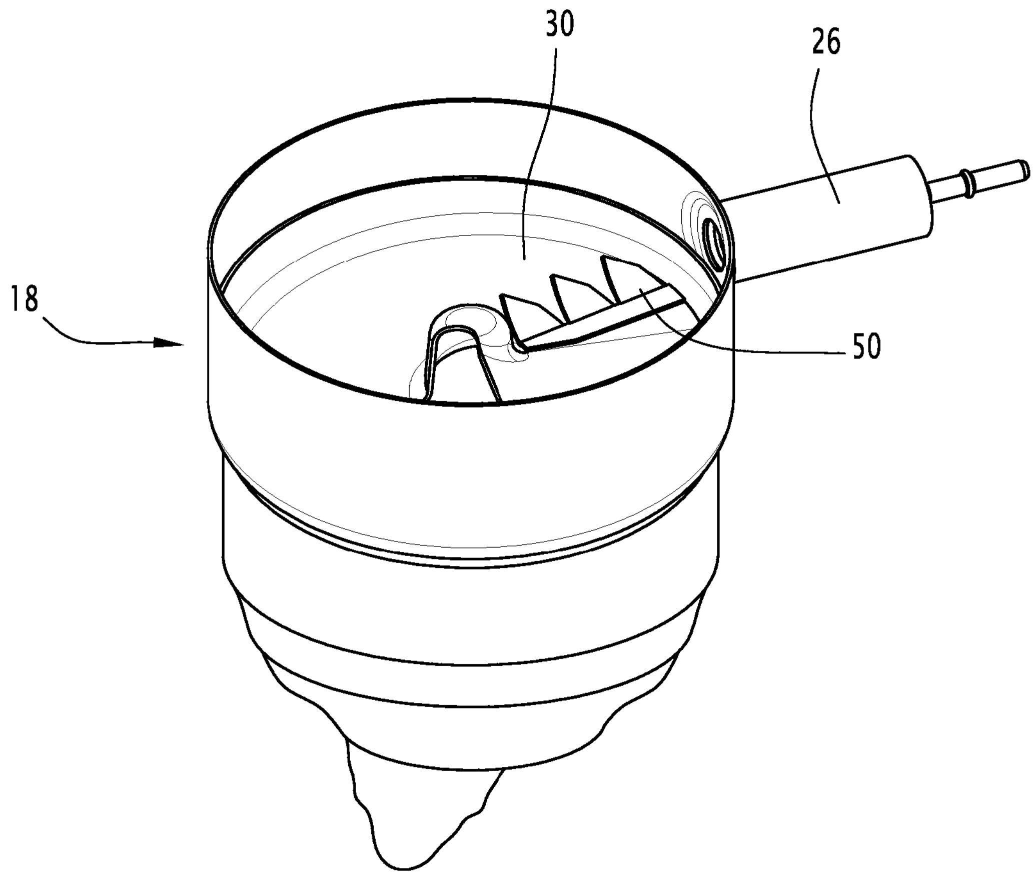


FIG.8

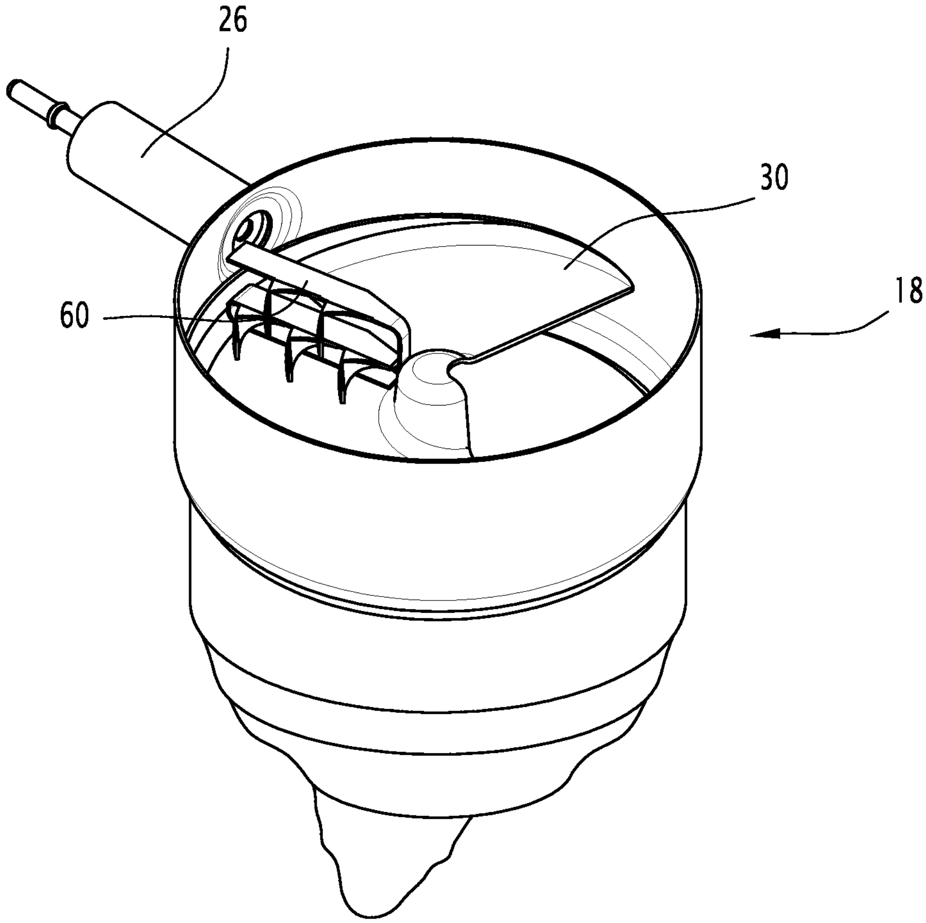


FIG.9

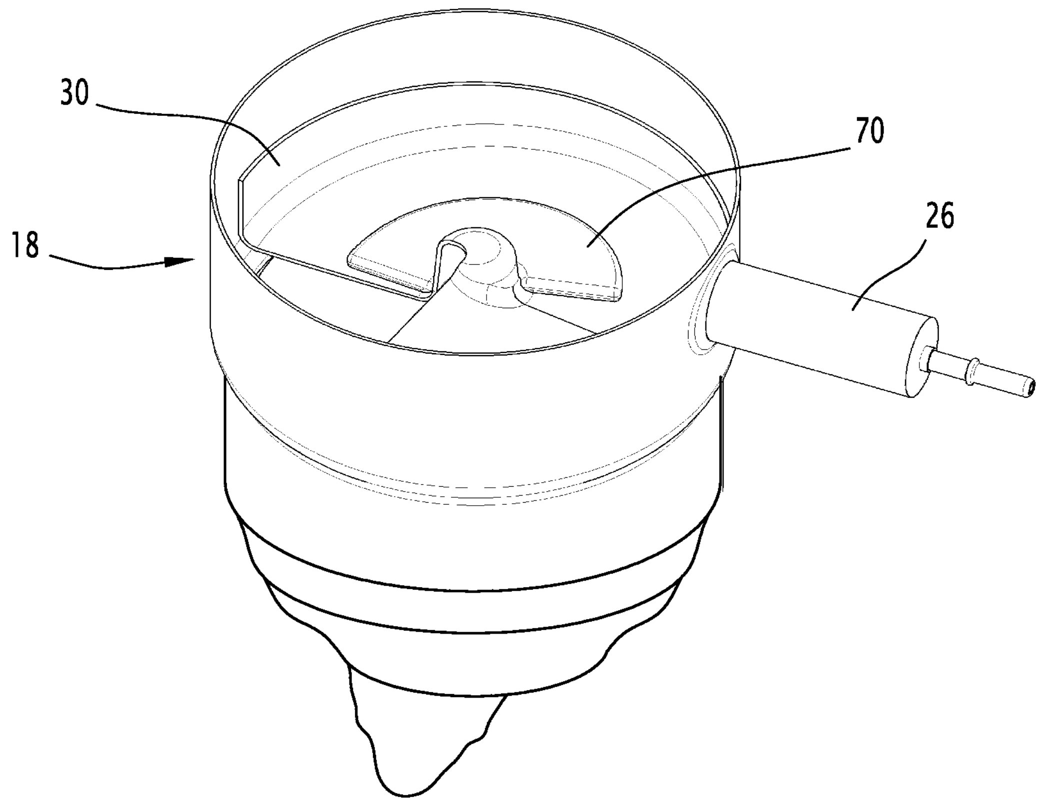


FIG.10

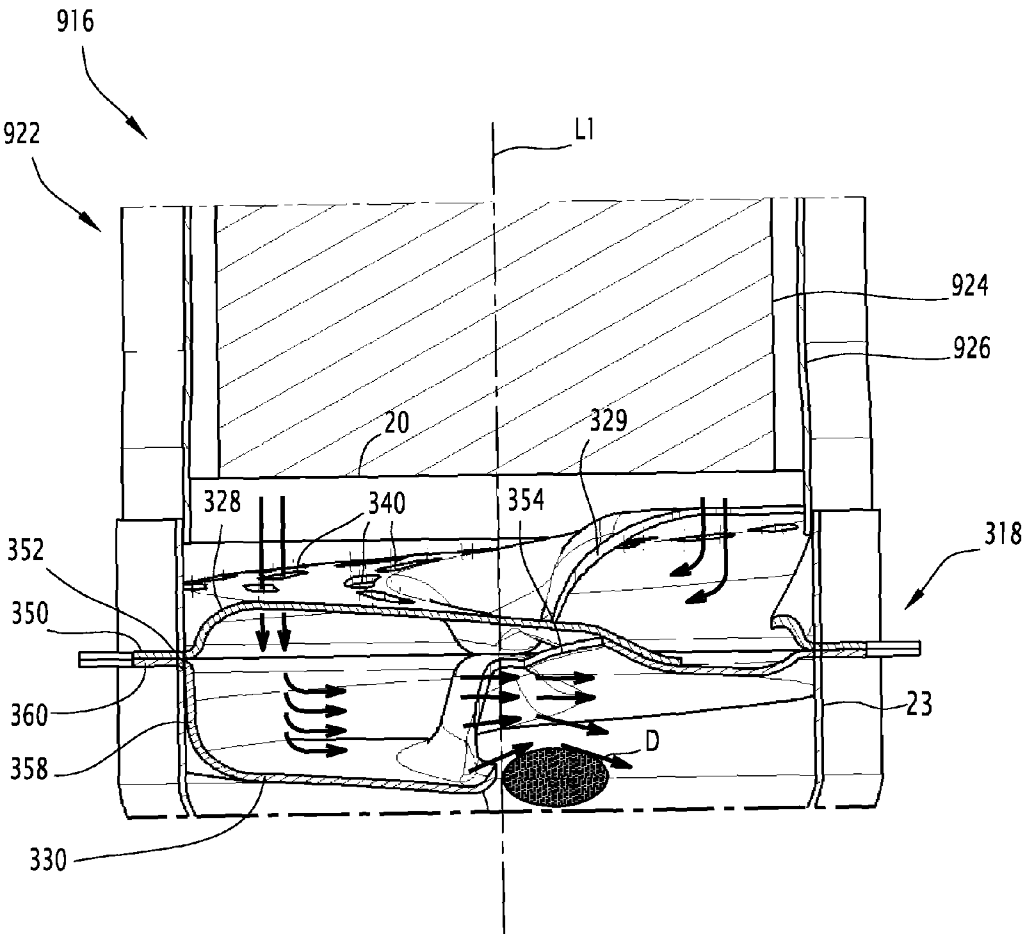
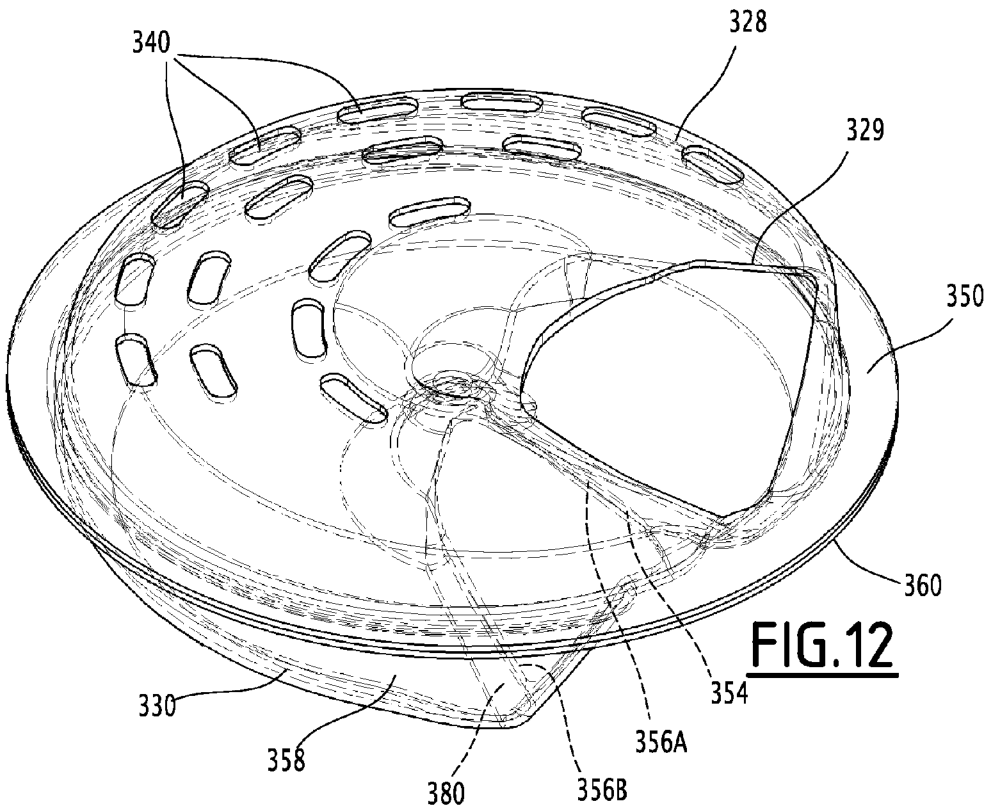


FIG.11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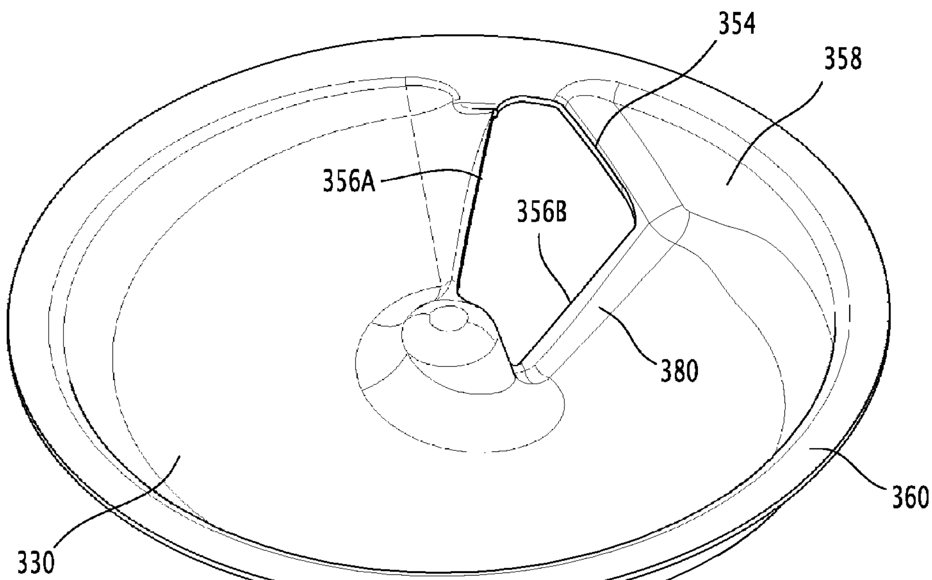
356A
380
356B

FIG.12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356B
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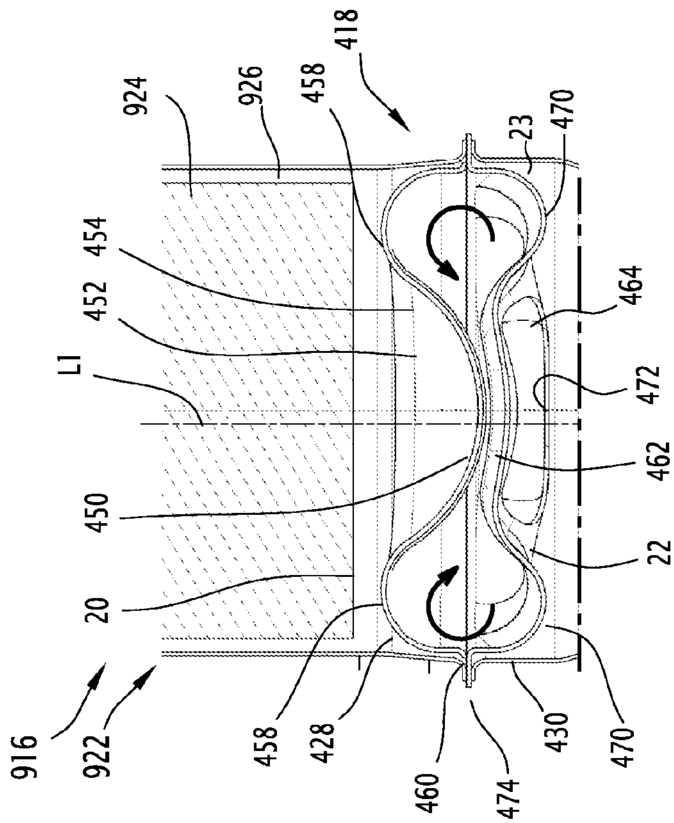
FIG.13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924
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L1
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22
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916
922
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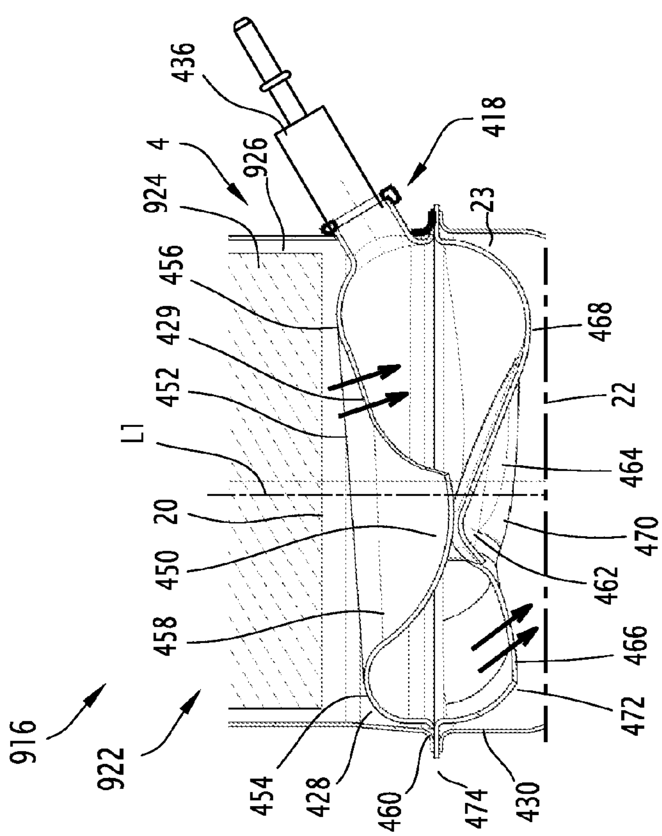
FIG.15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472
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FIG.14

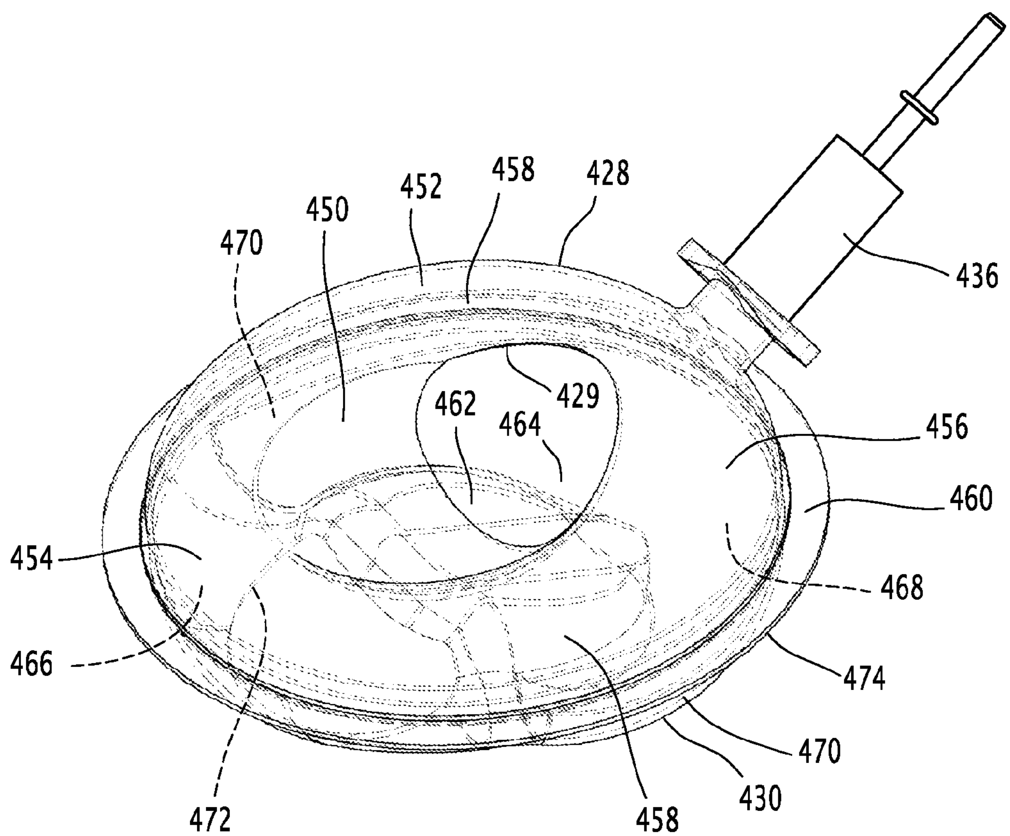

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FIG.16

MOTOR VEHICLE EXHAUST LINE

TECHNICAL FIELD

The present invention relates to a motor vehicle exhaust line of the type comprising: a hot pipe for exhaust gases; a cold pipe for the exhaust gases; a mechanical decoupling element connecting a downstream end of the hot pipe to an upstream end of the cold pipe; a nitrogen oxide treatment device; and an injector intended to inject a reagent into, or to produce a reagent in the exhaust line upstream of the nitrogen oxide treatment device.

BACKGROUND

Such an exhaust line is provided to equip an internal combustion engine, for example a diesel engine. It includes a catalyst provided to reduce the nitrogen oxides and an injector placed upstream from the catalyst. The injector is designed to inject a reagent, in particular a reducing agent or substance producing a reducing agent of the nitrogen oxides, such as urea, in the exhaust line. The urea consecutively undergoes two chemical reactions, thermolysis and hydrolysis, and is converted into ammonia. Within the catalyst and when the exhaust gases reach a certain temperature, the ammonia reacts chemically with the nitrogen oxides, reducing them into nitrogen and water.

In an exhaust line including an SCR system, i.e., the catalyst performing the selective reduction of the nitrogen oxides, the injection of the reducing agent is generally located downstream from the mechanical decoupling element to prevent damaging the latter, for example to avoid the risks of corrosion and mechanical failure. Such an arrangement nevertheless has the major drawback of increasing the startup time for the conversion of nitrogen oxides due to the distance of the SCR system from the engine.

In light of the aforementioned constraints, the architecture of such an exhaust line including an SCR system makes it more difficult to obtain an effective increase in the conversion of nitrogen oxides NO_x when the vehicle is traveling under urban conditions, as it is not possible to reach the threshold or minimum temperature authorizing the injection of the reducing agent quickly.

In this context, the invention aims to propose an exhaust line whereof the operation is more satisfactory, with a more effective conversion of the nitrogen oxides.

SUMMARY

To that end, the invention relates to an exhaust line of the aforementioned type, and which further includes a mixer intended to mix the exhaust gases and the reagent injected or produced by the injector. The mixer is positioned upstream of the nitrogen oxide treatment device, and the nitrogen oxide treatment device being positioned in the cold pipe downstream from the mechanical decoupling element. The injector and the mixer form an assembly connected directly to the mechanical decoupling element.

The assembly is formed by the injector and the mixer is inserted in the hot pipe directly upstream from the mechanical decoupling element.

The assembly is formed by the injector and the mixer is inserted in the cold pipe directly downstream from the mechanical decoupling element.

The nitrogen oxide treatment device is a selective reduction catalyst of the nitrogen oxides.

The exhaust line includes an oxidation catalyst positioned upstream from the assembly formed by the injector and the mixer.

The mixer includes an injection portion positioned between an upstream face and a downstream face respectively defined by an exhaust gas inlet into and an exhaust gas outlet outside the mixer. The injection portion includes an exhaust gas duct extending from the upstream face to the downstream face. The exhaust gas duct has a central line having a set length between the upstream and downstream faces. The injector includes a reagent injector mounted on the injection portion and capable of injecting or producing a reagent in the injection portion. The injection portion includes at least one first cup positioned inside the duct such that a mean path of the exhaust gases in the duct is at least 20% greater relative to the set length.

The set length is, in one example, between 40 and 140 mm.

The first cup has a bottom wound in a spiral around the central line of the injection portion.

The bottom of the first cup is wound in a spiral around the central line of the injection portion for performing three quarters of a revolution.

The first cup has an opening at an end of the spiral furthest from the upstream face.

The first cup includes a beak at the end of the spiral furthest from the upstream face.

The beak extends the bottom of the first cup toward the upstream face and toward the outside of the spiral.

The injection portion includes a second cup positioned inside the duct between the upstream face and the first cup. The second cup has a bottom winding in a spiral around the central line of the injection portion.

The second cup has an opening at the end of the spiral furthest from the upstream face.

The second cup has an opening at the end of the spiral closest to the upstream face.

The first and second cups define a spiral-shaped conduit between them, starting from the opening of the second cup and going to the opening of the first cup, extending over at least 180°, preferably 275°, and having a straight cross-section substantially larger than 2,300 mm^2.

The first cup includes a rounded wall having a central area protruding toward the upstream face and a hollow peripheral area turned toward the upstream face surrounding the protruding central area. An opening is formed in the wall of the first cup between the protruding central area and the hollow peripheral area.

The injection portion includes a second cup positioned inside the duct between the upstream face and the first cup. The second cup includes a rounded wall having a hollow central area turned toward the upstream face and a peripheral area protruding toward the upstream face surrounding the hollow central area. An opening is formed in the wall of the second cup between the hollow central area and the protruding peripheral area.

The first and second cups are configured to impart a helical movement to the exhaust gases from the opening of the second cup to the opening of the first cup.

The injection of the reagent is done between the first cup and the second cup.

The opening of the first cup and the opening of the second cup are angularly offset relative to one another around the central line.

The cup has perforations with a diameter substantially equal to 5 mm or an opening.

The first cup includes a wire mesh layer over at least part of its surface.

The reagent injector is oriented such that an injection direction is perpendicular to the injection portion.

The reagent injector is oriented such that the injection direction is parallel to the tangent to the injection portion.

These and other features may be best understood from the following drawings and specification.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood upon reading the following description, provided solely as an example and done in reference to the appended drawings, in which:

FIG. **1** is a diagrammatic perspective view of an exhaust line according to the invention;

FIG. **2** is a longitudinal cross-sectional view along line II-II of FIG. **1** and illustrating a first part of the exhaust line of FIG. **1** according to a first embodiment of the invention;

FIG. **3** is a longitudinal cross-sectional view along line III-III of FIG. **1** and illustrating a second part of the exhaust line of FIG. **1** according to a second embodiment of the invention;

FIG. **4** is an exploded perspective view of an injection portion according to a first embodiment of the invention;

FIG. **5** is an exploded perspective view of the injection portion of FIG. **4** illustrating its operation;

FIG. **6** is a compact perspective view of the injection portion of FIG. **4**;

FIG. **7** is a view of the injection portion of FIG. **4** provided with a device for homogenizing the gas/urea mixture;

FIG. **8** is a view of the injection portion of FIG. **4** provided with a device for homogenizing the gas/urea mixture;

FIG. **9** is a view of the injection portion of FIG. **4** provided with a device for homogenizing the gas/urea mixture;

FIG. **10** is a view of the injection portion of FIG. **4** provided with a device for homogenizing the gas/urea mixture;

FIG. **11** is a profile view of a second embodiment of an injection portion according to the invention;

FIG. **12** is a perspective view of the cups of the second embodiment of the injection portion of FIG. **11**;

FIG. **13** is a perspective view of one of the cups of the second embodiment of the injection portion of FIG. **11**;

FIG. **14** is a profile view of a third embodiment of the injection portion according to the invention;

FIG. **15** is another profile view of the third embodiment of the injection portion of FIG. **14**; and

FIG. **16** is a perspective view of the cups of the third embodiment of the injection portion of FIG. **14**.

DETAILED DESCRIPTION

In the following description, upstream and downstream will be understood relative to the normal direction of movement of the exhaust gases through the exhaust line, indicated by the arrows F in the Figures.

FIG. **1** shows an exhaust line **910** provided to be mounted on a motor vehicle equipped with an internal combustion engine, for example a diesel engine. The exhaust line **910** typically includes, positioned in series, an exhaust gas manifold at the outlet of the engine, optionally a turbocharger, at least one exhaust gas purifying device, and a muffler.

The pollutants resulting from the combustion of the diesel engine primarily comprise uncombusted hydrocarbons HC, nitrogen oxides NO_x (nitric oxide NO and nitrogen dioxide NO_2), carbon monoxide CO, and soot particles.

In a known manner, the device for purifying exhaust gases comprises at least one element from among a catalytic purifying member and/or a particle filter.

The catalytic purifying member is suitable for treating pollutant emissions in gaseous phase, while the particle filter is suitable for retaining the soot particles emitted by the engine and optionally for binding the gaseous pollutants.

The catalytic purifying member for example comprises a gas-permeable structure covered with catalytic metals favoring the oxidation of the combustion gases and/or the reduction of the nitrogen oxides.

The exhaust gas **910** comprises a hot pipe **912** for the exhaust gases positioned close to the engine of the vehicle and a cold pipe **914** for the exhaust gases positioned further from the engine, downstream from the hot pipe **912**.

The hot **912** and cold **914** pipes respectively include devices **916** and **918** for purifying the exhaust gases positioned in series and downstream from the engine.

The exhaust line **910** also comprises a mechanical decoupling element **920** sealably connecting the downstream end of the hot pipe **912** to the upstream end of the cold pipe **914**. The mechanical decoupling element **920** is crossed by the exhaust gases traveling from the hot pipe **912** to the cold pipe **914**.

This mechanical decoupling element **920**, for example, comprises a flexible sleeve made up of a wire mesh and sealed against the exhaust gases.

Alternatively, the mechanical decoupling element **920** is of the type described in document FR-2878563.

The mechanical decoupling element **920** makes it possible to compensate for the vibrations of the engine along the exhaust line **910**, between the different elements of the hot **912** and cold **914** pipes.

In reference to FIG. **2**, the first device **916** for purifying the exhaust gases comprises an oxidation catalyst (DOC) **922** including an upstream monolith **924** housed inside an outer enclosure **926**.

The outer enclosure **926** forms a shroud having a substantially constant transverse section over its entire length.

The first exhaust gas purifying device **916** also comprises an upstream enclosure portion **21** connected to and diverging toward the upstream end of the outer enclosure **926**, and a downstream enclosure portion **23** connected to and converging from the downstream end of the outer enclosure **926**.

The upstream enclosure portion **21** defines the exhaust gas inlet in the first exhaust gas purifying device **916**, with the downstream enclosure portion **23** defining the outlet for the exhaust gases from the first exhaust gas purifying device **916**.

The DOC **922** converts the HC and CO from the engine to meet anti-pollution standards, converts part of the NO into NO_2, and creates the exotherm that makes it possible to achieve temperature conditions that are favorable to the reduction reaction of the NO_x by a low-temperature reducing agent. It is essentially made up of precious metals (platinum, palladium, rhodium) positioned on an oxide substrate. The substrate can be made from cordierite or may be metallic, depending on its location in the exhaust line **910**.

Alternatively, the exhaust line **910** comprises a plurality of DOCs **922**, the different functions being able to be distributed among the different DOCs **922**, the primary function of all of the DOCs **922** being to treat the HC and CO.

As illustrated in FIG. **3**, the second exhaust gas purifying device **918** comprises a device **928** for treating the nitrogen oxides formed by a selective reduction catalyst of the nitrogen oxides (SCR).

The device **928** for treating the nitrogen oxides is thus inserted in the cold pipe **914** of the exhaust line **910** downstream from the mechanical decoupling element **920**.

The SCR catalyst **928** includes a downstream monolith **930** housed inside an outer enclosure **932**. The downstream monolith **930** is formed from a porous material, which is permeable to the exhaust gases. It is, for example, configured as a honeycomb. The material is typically formed from cordierite, silicon carbide or a metallic material. It is impregnated with catalytic material. Thus, the downstream monolith **930** is capable of trapping reducing chemical species injected by an injector, as will be explained in more detail later, and causing certain components, such as the nitrogen oxide contained in the exhaust gases, to react with said reducing species to reduce the nitrogen oxides, in particular into gaseous nitrogen.

The outer enclosure **932** forms a shroud having a substantially constant transverse cross-section over its entire length.

The second exhaust gas purifying device **918** also comprises an upstream enclosure portion **25** connected to and diverging toward the upstream end of the outer enclosure **932**, and a downstream enclosure portion **27** connected to and converging from the downstream end of the outer enclosure **932**.

The upstream enclosure portion **25** defines the exhaust gas inlet in the second exhaust gas purifying device **918**, with the downstream enclosure portion **27** defining the outlet of the exhaust gases from the second exhaust gas purifying device **918**.

The exhaust line **910** comprises (FIGS. **2** and **3**) an assembly formed by an injector **934** designed to inject or produce a reagent in the exhaust line **910** upstream from the nitrogen oxide treatment device **928** and a mixer **936** designed to mix the exhaust gases and the reagent injected or produced by the injector **934**.

According to a first embodiment of the invention illustrated in FIG. **2**, the assembly formed by the injector **934** and the mixer **936** is integrated into the first exhaust gas purifying device **916** and positioned downstream from the DOC **922**. This assembly is thus inserted in the hot pipe **912** of the exhaust line **910**, upstream from the SCR catalyst **928**.

The assembly formed by the injector **934** and the mixer **936** is directly connected to the mechanical decoupling element **920** and positioned directly upstream from the mechanical decoupling element **920**. In fact, in this first embodiment, no element other than the connecting hoses and/or enclosure portions is inserted between the assembly formed by the injector **934** and the mixer **936** and the mechanical decoupling element **920** situated downstream from that assembly. In particular, no exhaust gas purifying device, in particular no SCR catalyst, is positioned between the assembly and the mechanical decoupling element **920**.

The injector **934** includes a reagent injector **26** capable of injecting or producing a reagent in the mixer **936**. The reagent is typically a liquid solution of a nitrogen oxide reducing agent or a substance producing such a reducing agent. The reducing agent may be one or more hydrocarbon(s), partially oxidized hydrocarbonaceous species, ammonia, or a compound generating ammonia by chemical decomposition. The reagent may also assume a gaseous form, such as ammonia gas. Preferably, the reagent injector **26** is provided to inject a mixture of water and urea in the form of droplets inside the mixer **936**.

The injector **934** also includes a supply line for supplying the reagent injector **26** with liquid to be injected, and a control to allow or prohibit the supply of the reagent injector **26** by the supply line. The control is, for example, a valve controlled by a computer.

The mixer **936** includes an injection portion **18** according to a first embodiment of the invention illustrated in FIGS. **4** to **6**.

The injection portion **18** is positioned between an upstream face **20** defined by the upstream monolith **924** of the oxidation catalyst **922** and a downstream face **22** defined, for example, by a plane from which the transverse cross-section of the downstream enclosure portion **23** begins to decrease.

Thus, the upstream face **20** is the face by which the exhaust gases leave the upstream monolith **924** and enter the mixer **936**, and the downstream face **22** is the face by which the exhaust gases leave the mixer **936** and enter the mechanical decoupling element **920**, via the downstream enclosure portion **23** and optionally connecting hoses.

The injection portion **18** comprises a duct **24** allowing a stream of exhaust gas to pass from the upstream face **20** to the downstream face **22**.

The reagent injector **26** is mounted on the injection portion **18** and is capable of injecting a reagent into the injection portion **18**.

The duct **24** has a central line L**1** having a set length between the upstream **20** and downstream **22** faces. The central line L**1** is the line passing through the geometric centers of the straight cross-sections of the duct **24**. In the illustrated example, it is the straight line parallel to the axis of the upstream monolith **924**. It is perpendicular to the upstream **20** and downstream **22** faces and passes through their centers.

The injection portion **18** includes a cup **28** positioned inside the duct **24** in the path of the exhaust gas stream. That cup **28** is called a weir. The weir **28** has a bottom winding in a spiral around the central line L**1** of the injection portion **18** and a large opening **29** at the end of the spiral furthest from the upstream face **20**. The opening **29** is inclined both relative to the central line L**1** and relative to a plane perpendicular to the central line L**1**.

The diameter of the cup **28** is equal to the inner diameter of the exhaust gas ducts **24**. It extends in the entire straight cross-section of the duct **24**. The peripheral edge of the cup **28** bears against the inner surface of the duct **24**.

The spiral shape of the weir **28** initiates the rotary movement of the exhaust gases, the only way out being downstream. The exhaust gases perform approximately one complete revolution.

The uppermost part of the weir **28** is approximately 6 mm from the outlet face **20** of the upstream monolith **924**. According to one alternative, this distance may be increased up to 10 mm to avoid excessively increasing the back pressure.

Furthermore, the injection portion **18** includes a second cup **30**, called "channel," positioned inside the duct **24** between the first cup **28** and the downstream face **22**, the second cup **30** having a bottom winding in a spiral around the central line L**1** of the injection portion **18**.

Preferably, the bottom of the second cup **30** winds in a spiral around the central line L**1** of the injection portion **18** while performing three quarters of a revolution.

The second cup **30** has an opening at the end of the spiral furthest from the upstream face **20**. That opening is limited by the two end edges of the spiral-shaped bottom of the second cup **30** and the wall of the duct **24**.

The diameter of the second cup **30** is equal to the inner diameter of the exhaust gas duct **24**. It extends in the entire straight cross-section of the duct **24**, the peripheral edge of the cup **30** bearing against the inner surface of the duct **24**.

The two cups **28**, **30** define a spiral-shaped conduit between them, going from the opening **29** of the weir **28** to the opening of the cup **30** and extending over at least 180°, preferably 275°. The spiral-shaped conduit is laterally limited by the inner surface of the duct **24**.

The spiral-shaped conduit and the openings of the cups offer the exhaust gases a cross-section substantially greater than 2,300 mm^2 and preferably at least 2,375 mm^2. This cross-section corresponds to a section of a tube with a diameter of 55 mm, commonly used in exhaust lines and in particular in the injection area.

The opening of the first cup **28** and the opening of the second cup **30** are angularly offset relative to one another around the central line L**1**, to prevent any direct path parallel to the central line L**1** of the injection portion of the exhaust gas stream.

The injection portion has a cylindrical side wall with a diameter of approximately 150 mm, i.e., substantially equal to the diameters of the gas treatment devices, and a length comprised between 40 and 140 mm. Preferably, the distance between the upstream face **20** and the downstream face **22** is comprised between 60 and 100 mm.

The side wall is integral with the downstream enclosure portion **23**.

The first and second cups are fixed to the side wall, for example, by welds.

The side wall comprises an opening intended to insert and fasten the reagent injector **26**, the reagent here being urea, to the wall between the first cup **28** and the second cup **30**. The injector is oriented so that the injection direction is perpendicular to the side wall.

According to one alternative, the injector is oriented such that the injection direction has an angle comprised between 40° and 45° relative to the tangent to the side wall so as to make the jet co-current with the exhaust gas.

According to another alternative shown in mixed lines in FIG. **6**, the injector **26** is oriented such that the injection direction is parallel to the tangent to the side wall, thereby making it possible to obtain a more compact injection portion **18**.

According to another alternative, the first cup **28** comprises a local deflector to prevent contact between the jet of urea droplets and the upstream monolith **924**. For example, the local deflector is formed by cutting out the first cup.

The operation of the exhaust line described above will now be outlined, in light of FIG. **5**, in which exhaust gas stream lines are illustrated.

After having passed through the upstream monolith **924**, the exhaust gases leave the upstream monolith **924** with a substantially uniform distribution. The exhaust gas stream is laminar and substantially parallel to the central line L**1**. The exhaust gases arrive on the first cup **28**. The travel of the gases parallel to the central line L**1** is blocked by the first cup **28**, the spiral shape of which initiates the rotary movement of the gases.

The gases then enter the channel **30**, the spiral shape of which maintains the rotary movement of the exhaust gases.

At the outlet of the first cup **28** or weir, the urea is injected into the upstream portion of the channel **30**. The conversion of the urea into ammonia occurs during the passage of the gases in the channel **30**, i.e., during the time necessary for the gas to perform three quarters of revolution. The mean distance traveled by the exhaust gases during those three quarters of a revolution is approximately 180 mm. That distance corresponds to the distance necessary to convert the urea into ammonia if an injector is used that has a jet characterized by a mean diameter (SMD) of 90 μm, a discharge speed of 25 ms, and a dispersion angle of 16°.

Once the gases have reached the opening or outlet of the channel **30**, they pass through the downstream enclosure portion **23** and optionally connecting hoses to enter the mechanical decoupling element **920**.

The gases that reach this stage have on average already performed slightly more than one revolution; they have therefore acquired a significant tangential velocity and "attack" the downstream surface **22** with that component. It is known that this manner of arriving on a surface favors the obtainment of a good, uniform distribution on said surface.

The injection portion **18** typically has a length of only 60 mm and a diameter of 150 mm, i.e., the diameter of the outer enclosure surrounding the upstream monolith. Thus, as illustrated in FIG. **6**, the injection portion is contained in a cylinder with a diameter of 60×150 mm and makes it possible to increase the mean path of the exhaust gas stream lines by at least 20% relative to the set length between the upstream face **20** and the downstream face **22**.

Furthermore, if the gas flow rate is different from the example cited above, then the length of the cylinder will be different to form a necessary passage section. If the flow rate is higher, then the distance between the upstream and downstream faces will need to be increased. If it is lower, that distance will then be able to be decreased.

This embodiment can be used in a horizontal or vertical portion, under a floor or under a manifold (in the close position) of a motor vehicle.

This system of course works with all types of urea injectors, but the characteristics of these different injectors clearly has a wide range of jets. These jets have wide or narrow cones, variable mean diameters for very fine or very large droplets, and higher or lower discharge speeds.

Consequently, to ensure optimal homogenization, as shown in FIG. **7**, the first cup **28** includes perforations **40** with a diameter substantially equal to 5 mm.

For example, if the injector **26** has a jet with little energy and very fine droplets, then the urea droplets will not penetrate the gaseous stream deeply. The concentration of urea on the outer edge of the channel **30** will therefore be greater than the concentration at the center. The presence of perforations **40** of the weir **28** above the outer edge of the channel **30** will allow the gas leaving the upstream monolith **924** to short-circuit the inlet of the channel **30** and deplete the urea/air ratio at the periphery of the channel **30**.

Conversely, if the characteristics of the injector **26** are such that a large portion of the urea is located inside, in the central portion, of the channel **30**, the perforations **40** will overhang that area.

In one alternative illustrated in FIGS. **8** and **9**, the injection portion **18** includes a linear mixer situated between the two cups to create obstacles that aim to disrupt the stream to homogenize the exhaust gases and the urea or ammonia. This mixer may assume the form of fins **50** or raised tongues fastened on the second cup **30** and oriented toward the first cup **28** (not shown here) as shown in FIG. **8**, or a helical shape **60** as shown in FIG. **9**.

According to another alternative shown in FIG. **10**, the second cup **30** includes a wire mesh layer **70** positioned on at least part of the surface of the second cup **30**. Positioning the second cup **30** independently of the other pieces making up the injection portion **18** before assembly makes it possible to deposit a wire mesh layer **70** in the locations where it is necessary to optimize the evaporation and the conversion of the urea into ammonia. In fact, it is very difficult to deposit a wire mesh layer **70** in an exhaust tube. In a known manner, adding a wire mesh layer **70** makes it possible to increase the contact surface between the urea and the exhaust gases by significantly increasing the metal/gas exchange surface.

In FIG. **10**, the portion of the channel **30** covered by the wire mesh **70** is hotter than an outer wall; consequently, the evaporation and the conversion of the urea into ammonia will be easier and faster there.

It is also possible to fix a wire mesh layer **70** on the lower portion of the first cup **28** (not shown here) across from the second cup **30**.

It is understood that the injection portion **18** may include one or more of these alternatives designed to obtain optimal homogenization of the gas/ammonia mixture, considered individually or according to all technically possible combinations.

A second embodiment of the injection portion **318** is illustrated in FIGS. **11** (profile view), **12** and **13** (perspective views). The injection portion **318** comprises a first cup **328** and a second cup **330**.

The downstream enclosure portion **23** is fastened, sealed against the exhaust gases, to the lower portion of the outer enclosure **926** of the oxidation catalyst **922**. The two cups **328**, **330** are inside the downstream enclosure portion **23**.

The first cup **328** has a bottom winding in a spiral around the central line L**1** of the injection portion **318**. The first cup **328** has a concavity turned toward the downstream face **22**, such that the bottom of the first cup **328** forms a lid of the second cup **330**.

The first cup **328** has a large opening **329** at the end of the spiral closest to the upstream face **20**. The opening **329** is inclined both relative to the central line L**1** and relative to a plane perpendicular to the central line L**1**.

The first cup **328** has a peripheral rim **350** extending the bottom of the first cup **328** and extending substantially perpendicular to the central line L**1**, the peripheral rim **350** passing through a peripheral lumen **352** formed in the upstream portion of the downstream enclosure portion **23**. The peripheral rim **350** of the first cup **328** is fastened, sealed against the exhaust gases, to the downstream enclosure portion **23**, for example by welding.

The bottom of the first cup **328** also includes perforations **340** making it possible to ensure optimal homogenization of the exhaust gases.

The second cup **330** is positioned between the first cup **328** and the downstream face **22**, with the second cup **330** having a bottom winding in a spiral around the central line L**1** of the injection portion **318**.

Preferably, the bottom of the second cup **330** winds in a spiral around the central line L**1** of the injection portion **318** while performing at least three quarters of a revolution.

The second cup **330** has an opening **354** at the end of the spiral furthest from the upstream face **20**. This opening **354** is limited by the two end edges **356**A, **356**B of the spiral-shaped bottom of the second cup **330** and by the peripheral wall **358** of the second cup **330**, the peripheral wall **358** of the second cup **330** bearing against the inner surface of the duct.

The second cup **330** has a peripheral rim **360** extending the peripheral wall **358** of the second cup **330** and extending substantially perpendicular to the central line L**1**, the peripheral rim **360** passing through the peripheral lumen **352** formed in the upstream portion of the outer enclosure portion **23**. The peripheral rim **360** of the second cup **330** is fastened, sealed against the exhaust gases, to the outer enclosure portion **23**, for example by welding.

The peripheral rims **350**, **360** of the first and second cups **328**, **330** are thus positioned across from and in contact with each other, and are fastened to each other, sealed against the exhaust gases, for example, by welding.

The two cups **328**, **330** define a spiral-shaped conduit between them, going from the opening **329** of the first cup **328** to the opening **354** of the second cup **330** and extending over at least 180°, preferably over at least 275°.

The second cup **330** also includes a beak **380** positioned at its downstream end, i.e., the end of the spiral furthest from the upstream face **20**. The beak **380** extends the bottom of the second cup **330** toward the upstream face **20** and toward the outside of the spiral conduit, and is defined by the end edge **356**B. The beak **380** thus forms a convex groove opening toward the upstream face **20**.

As an example, the beak **380** has a curve radius of 5.5 mm and a height of 7 mm, the height of the beak **380** being able to be increased up to 10 mm. The beak **380** extends angularly over 10°, that value being able to be increased up to 90°.

The beak **380** makes it possible to limit the ammonia concentration just after the opening **354**, as will be explained in more detail later.

The reagent injector (not shown) is provided to inject into the spiral-shaped conduit defined by the two cups **328**, **330**. To that end, it is fastened on the bottom of the first cup **328**, near the opening **329**.

According to one alternative, the injector is fastened on the peripheral wall **358** of the second cup **330**.

The operation of the exhaust line according to the second embodiment described above will now be outlined, in light of FIG. **11**, in which the exhaust gas stream is shown by arrows.

As before, the exhaust gases arrive on the first cup **328**. The gases are collected by the first cup **328** after having passed through the upstream monolith **924**.

Then, the exhaust gases penetrate the spiral-shaped conduit through the opening **329** or through the perforations **340** and circulate in the spiral-shaped conduit as far as the opening **354**.

At the inlet of the spiral-shaped conduit, the urea is injected and is converted into ammonia during the passage of the exhaust gases in the spiral-shaped conduit.

At the outlet of the spiral-shaped conduit, the beak **380** forces the lower layer of exhaust gas, i.e., the layer of gas close to the second cup **330** and highly charged with ammonia, to change direction abruptly to be oriented upward, i.e., toward the upstream face **20**, and to mix with the layer of gas situated just above it, that median layer being less charged with ammonia. The exhaust gases at the outlet of the second cup **330** then have a mean and homogenous ammonia concentration.

Furthermore, the sudden deviation of the lower layer of gas by the beak **380** creates a vacuum just at the outlet of the second cup **330**, in the area referenced D in FIG. **11**. This vacuum suctions the exhaust gases situated between the outlet of the second cup **330** and the downstream face **22**, allowing better rotation of the exhaust gases on the downstream face **22**.

As an example, in the case of an injection portion **318** with a diameter of 150 mm and 70 mm long, the uniformity index of the ammonia on the downstream face **22** is increased from 5 to 9 one hundredths.

Furthermore, as in the previous cases, a linear mixer may be integrated inside the spiral-shaped conduit and/or part of the walls of the spiral-shaped conduit may include a wire mesh so as to ensure optimal homogenization of the gases and the urea and/or ammonia.

The advantage of this embodiment is that the distribution of the ammonia on the downstream face **22** is improved, the ammonia thus being uniformly distributed on the downstream face.

A third embodiment of the injection portion **418** is illustrated in FIGS. **14**, **15** (profile views) and **16** (perspective view). The injection portion **418** comprises a first cup **428** and a second cup **430**.

The downstream enclosure portion **23** is fastened, sealed against the exhaust gases, to the outer enclosure **926** of the oxidation catalyst **922** by the second cup **430**. The first and second cups **428**, **430** are positioned at the junction between the upstream outer enclosure **926** and the downstream enclosure portion **23**, the first cup **428** being inside the upstream outer enclosure **926** and the second cup **430** being inside the downstream enclosure portion **23**.

The first cup **428** opens toward the downstream face **22** and includes a rounded wall with no sharp edges. This wall has a hollow central area **450** turned toward the upstream face **20** and a peripheral area **452** protruding toward the upstream face **20** surrounding the hollow central area **450**. The protruding peripheral area **452** comprises a lower peripheral portion **454** and an upper peripheral portion **456** opposite each other, the lower peripheral portion **454** having an axial height along the central line L**1** that is reduced relative to that of the upper peripheral portion **456**. The lower **454** and upper **456** peripheral portions are connected to each other by two opposite side peripheral portions **458**.

The first cup **428** is symmetrical relative to the plane passing through the central line L**1** of the injection portion **418** and the reagent injector **436** (FIG. **15**).

A large opening **429** is formed in the wall of the first cup **428** between the hollow central area **450** and the upper peripheral portion **456** of the protruding peripheral area **452**. The opening **429** is inclined both relative to the central line L**1** and relative to a plane perpendicular to the central line L**1**. The opening **429** has a substantially rounded triangular shape, one of the apices being located toward the injector **436**.

The first cup **428** has a peripheral rib **460** extending the wall of the first cup **428** and extending substantially perpendicular to the central line L**1**. The peripheral rim **460** of the first cup **428** is fastened, sealed against the exhaust gases, to the second cup **430**, for example by welding.

The second cup **430** is positioned between the first cup **428** and the downstream face **22**.

The second cup **430** opens toward the upstream face **20** and includes a rounded wall with no sharp edges. This wall has a central area **462** protruding toward the upstream face **20** and a hollow peripheral area **464** turned toward the upstream face **20** surrounding the central area **462**. The hollow peripheral area **464** comprises a lower peripheral portion **466** and an upper peripheral portion **468** that are opposite each other, the lower peripheral portion **466** having an axial height along the central line L**1** that is reduced relative to that of the upper peripheral portion **468**. The lower **466** and upper **468** peripheral portions are connected to each other by two opposite peripheral side portions **470**.

The second cup **430** is symmetrical relative to the plane passing through the central line L1 of the injection portion **418** and through the reagent injector **436** (FIG. **15**).

An opening **472** is formed in the wall of the second cup **430** between the central protruding area **462** and the lower peripheral portion **466** of the hollow peripheral area **464**. The opening **472** is inclined relative to the central line L**1** and relative to a plane perpendicular to the central line L**1**. The opening **472** is in the shape of a rounded crescent moon, the large side being located across from the injector **436**.

The opening **429** of the first cup **428** and the opening **472** of the second cup **430** are angularly offset relative to each other around the central line L**1** by substantially 180°.

According to one alternative, a second opening is provided in the wall of the first cup **428** between the hollow central area **450** and the lower peripheral portion **454** of the protruding peripheral area **452**, opposite the injector **436** and substantially at the opening **472** of the second cup **430**, so as to short-circuit the opening **429** so that part of the gases directly reaches the opening **472** without passing through the duct, thereby decreasing the back pressure.

The second cup **430** has a peripheral rim **474** extending the wall of the second cup **430** and extending substantially perpendicular to the central line L**1**. The peripheral rim **474** of the second cup **430** is fastened, sealed against the exhaust gases, to the upstream outer enclosure **926** and the downstream enclosure portion **23** as well as the peripheral rim **460** of the first cup **428**, for example by welding.

When assembled, the two cups **428**, **430** are in the form of a "doughnut" and define two semi-annular conduits between them, going from the opening **429** of the first cup **428** to the opening **472** of the second cup **430**.

The reagent injector **436** is provided to inject into the two semi-annular conduits defined by the two cups **428**, **430**. To that end, it is fastened on the upper peripheral portion **456** of the peripheral area **452** of the first cup **428**, near the opening **429**. The injector **436** is oriented substantially at 45° relative to the central line L**1** such that the jet is oriented toward the central protruding area **462** of the second cup **430**.

According to one alternative, the injector **436** is oriented such that the injection direction is perpendicular to the two semi-annular conduits.

According to another alternative, the injector **436** is oriented such that the injection direction is parallel to the tangent to two semi-annular conduits, thereby making it possible to obtain a more compact injection portion **418**.

The operation of the exhaust line according to the third embodiment described above will now be outlined, in light of FIGS. **14** and **15**, in which the exhaust gas stream is shown by arrows.

As before, the exhaust gases arrive on the first cup **428**. The gases are collected by the first cup **428** after having passed through the upstream monolith **924**.

Then, the exhaust gases penetrate the duct through the opening **429** (FIG. **14**).

At the inlet of the duct, the urea is injected and is converted into ammonia during the passage of the exhaust gases in the duct.

Due to the orientation of the injector **436**, the gas stream is distributed between the two semi-annular conduits.

The first part of the gas stream thus uses one of the semi-annular conduits and travels along that conduit following a helical movement around the central line of that conduit to the opening **472**. The rounded shape of the two cups **428**, **430** initiates the rotary movement of that first part of the gas stream, which performs at least one complete revolution, or up to four complete revolutions, around the central line, in a counterclockwise direction in FIG. **15**.

During that time, a second part of the gas stream uses the other of the semi-annular conduits and travels along that conduit following a helical movement around the central line of that conduit up to the opening **472**. The rounded shape of the two cups **428**, **430** initiates the rotary movement of that second part of the gas stream, which performs at least one complete revolution, or up to four complete revolutions, around the central line, in the clockwise direction in FIG. **15**.

Once the gases have passed through the opening **472**, they will pass through the decoupling element **920**, via the downstream enclosure portion **23** and optionally connecting hoses.

Furthermore, as in the preceding cases, a linear mixer may be integrated inside the duct and/or part of the walls of the duct may include a wire mesh so as to ensure optimal homogenization of the gases and the urea and/or ammonia.

The advantage of this embodiment is that it allows excellent mixing of the gases and the urea and/or ammonia.

The exhaust line according to the invention has the advantage of reducing the distance between the upstream and downstream faces while preserving a sufficient path length of the gases to ensure the conversion of the urea into ammonia. The path is long enough for the reaction that converts the urea, injected into the exhaust gases, into ammonia to be complete, but also for the final exhaust gas/ammonia mixture to be as homogenous as possible.

Thus, the exhaust line according to the first embodiment of the invention makes it possible to protect the mechanical decoupling element from deposits, the risks of corrosion and other mechanical failures. In fact, the assembly of the injection/mixer is very compact and makes it possible to ensure the total decomposition of the urea into ammonia in a reduced bulk, in particular before the exhaust gases pass through the mechanical decoupling element.

Furthermore, the exhaust line according to the invention makes it possible to convert the urea as early as possible, i.e., very quickly after the vehicle is started. In fact, because the assembly of the injection/mixing is positioned quite far upstream in the exhaust line, the cups of the mixer will reach the decomposition temperature of the urea, which is approximately 180° C., very early during the travel cycle. However, this decomposition temperature is decisive for starting the SCR catalyst, which is done at a temperature of approximately 150 to 160° C.

According to a second embodiment of the invention illustrated in FIG. **3**, the assembly formed by the injector **934** and the mixer **936** is integrated into the second exhaust gas purifying device **918** and positioned upstream of the SCR catalyst **928**. This assembly is thus inserted in the cold pipe **914** of the exhaust line **910** (FIG. **1**).

The assembly formed by the injector **934** and the mixer **936** is directly connected to the mechanical decoupling element **920** and positioned directly downstream from the mechanical decoupling element **920**. In fact, in the second embodiment, no elements other than the connecting hoses and/or enclosure portions are inserted between the assembly formed by the injector **934** and the mixer **936** and the mechanical decoupling element **920** situated downstream from that assembly. In particular, no exhaust gas purifying device, in particular no DOC, is positioned between the assembly and the mechanical decoupling element **920**.

The injector **934** and the mixer **936** are identical to those described for the first embodiment, the injection portion **18** being positioned between an upstream face **20**, for example defined by a plane from which the transverse section of the upstream enclosure portion **25** stops increasing and is substantially constant, and a downstream face **22** defined by the downstream monolith **930** of the SCR catalyst **928**.

Thus, the upstream face **20** is the face by which the exhaust gases leave the mechanical decoupling element **920**, via the upstream enclosure portion **25** and optionally connecting hoses, and enter the mixer **936**, and the downstream face **22** is the face by which the exhaust gases leave the mixer **936** and enter the downstream monolith **930**.

Thus, the exhaust line according to the second embodiment of the invention makes it possible to improve the start of the SCR catalyst. In fact, the injector mixer assembly being very compact, the distance between the mechanical decoupling element and the SCR catalyst is limited. Thus, the heat exchanges with the outside are limited, which makes it possible to preserve the energy necessary for the evaporation of the urea, then the conversion of the urea as well as the beginning of the SCR catalyst reactions, without needing to isolate in any way.

Furthermore, because the cups of the mixer are at the temperature of the exhaust gases, this makes it possible to limit the appearance of deposits on those cups. In fact, when the cups are at the temperature of the exhaust gases, the temperature is sufficient to completely evaporate the water and the urea.

Furthermore, the injection of the urea being done downstream from the mechanical decoupling element, the latter is saved from any deposit related to the urea or its conversion.

The invention therefore makes it possible, using a compact injector mixer assembly, to place that assembly at different locations in the exhaust line.

The closer this assembly is positioned to the engine, the more effective and inexpensive the depollution of the exhaust gases is to perform, the decomposition temperature of the urea being reached quickly and maintained using cost-effective materials used for the mixer.

When it is not possible to bring the assembly closer to the engine, for example when the space available under the floor is not sufficient, the invention nevertheless makes it possible to perform an effective conversion of the nitrogen oxides early in the travel of the vehicle. In fact, the geometry of the compact assembly ensures, over a very short distance, the conversion of the urea into ammonia, the homogenization of the exhaust gas/ammonia mixture, a good ammonia distribution at the inlet of the SCR catalyst and the beginning thereof, and all as early as possible during the travel of the vehicle.

Furthermore, the exhaust line according to the invention is compatible with the injection of a reducing agent in gaseous form, in particular ammonia. In that case, the urea injector is replaced with an injection system specific to ammonia.

Although an embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this disclosure. For that reason, the following claims should be studied to determine the true scope and content of this disclosure.

The invention claimed is:

1. A motor vehicle exhaust line of the type comprising:

a hot pipe for exhaust gases;

a cold pipe for the exhaust gases;

a mechanical decoupling element connecting a downstream end of the hot pipe to an upstream end of the cold pipe;

a nitrogen oxide treatment device;

an injector intended to inject a reagent into, or to produce a reagent in the exhaust line upstream of the nitrogen oxide treatment device;

a mixer intended to mix the exhaust gases and the reagent injected or produced by the injector, said mixer being positioned upstream of the nitrogen oxide treatment device, the nitrogen oxide treatment device being positioned in the cold pipe downstream from the mechanical decoupling element, and the injector and the mixer forming an assembly connected directly to the mechanical decoupling element; and

wherein the mixer includes an injection portion positioned between an upstream face and a downstream face respectively defined by an exhaust gas inlet into and an exhaust gas outlet outside the mixer, the injection portion comprising an exhaust gas duct extending from the upstream face to the downstream face, the exhaust gas duct having a central line having a set length between the upstream and downstream faces, the injector including a reagent injector mounted on the injection portion and capable of injecting or producing a reagent in the injection portion, the injection portion comprising at least one first cup positioned inside the exhaust gas duct such that a mean path of the exhaust gases in the exhaust gas duct is at least 20% greater relative to the set length.

2. The exhaust line according to claim 1, wherein the assembly is formed by the injector and the mixer is inserted in the hot pipe directly upstream from the mechanical decoupling element.

3. The exhaust line according to claim 1, wherein the assembly is formed by the injector and the mixer is inserted in the cold pipe directly downstream from the mechanical decoupling element.

4. The exhaust line according to claim 1, wherein the nitrogen oxide treatment device is a selective reduction catalyst of nitrogen oxides.

5. The exhaust line according to claim 1, including an oxidation catalyst positioned upstream from the assembly formed by the injector and the mixer.

6. The exhaust line according to claim 1, wherein the set length is substantially comprised between 40 and 140 mm.

7. The exhaust line according to claim 1, wherein the at least one first cup has a bottom wound in a spiral around the central line of the injection portion.

8. The exhaust line according to claim 7, wherein the bottom of the at least one first cup is wound in a spiral around the central line of the injection portion for performing three quarters of a revolution.

9. The exhaust line according to claim 7, wherein the at least one first cup has an opening at an end of the spiral furthest from the upstream face.

10. The exhaust line according to claim 7, wherein the at least one first cup includes a beak at an end of the spiral furthest from the upstream face.

11. The exhaust line according to claim 10, wherein the beak extends the bottom of the first cup toward the upstream face and toward the outside of the spiral.

12. The exhaust gas line according to claim 1, wherein the injection portion includes a second cup positioned inside the exhaust gas duct between the upstream face and the first cup, the second cup having a bottom winding in a spiral around the central line of the injection portion.

13. The exhaust line according to claim 12, wherein the second cup has an opening at an end of the spiral furthest from the upstream face.

14. The exhaust line according to claim 13, wherein the opening of the first cup and the opening of the second cup are angularly offset relative to one another around the central line.

15. The exhaust line according to claim 12, wherein the second cup has an opening at an end of the spiral closest to the upstream face.

16. The exhaust line according to claim 12, wherein the first and second cups define a spiral-shaped conduit between them, starting from an opening of the second cup and going to the opening of the first cup, extending over at least 180°, preferably 275°, and having a straight cross-section substantially larger than 2,300 mm^2.

17. The exhaust line according to claim 12, wherein the injection of the reagent is done between the first cup and the second cup.

18. The exhaust line according to claim 1, wherein the first cup includes a rounded wall having a central area protruding toward the upstream face and a hollow peripheral area turned toward the upstream face surrounding the protruding central area, an opening being formed in the wall of the first cup between the protruding central area and the hollow peripheral area.

19. The exhaust gas line according to claim 18, wherein the injection portion includes a second cup positioned inside the exhaust gas duct between the upstream face and the first cup, the second cup including a rounded wall having a hollow central area turned toward the upstream face and a peripheral area protruding toward the upstream face surrounding the hollow central area, and an opening being formed in the wall of the second cup between the hollow central area and the protruding peripheral area.

20. The exhaust line according to claim 19, wherein the first and second cups are configured to impart a helical movement to the exhaust gases from the opening of the second cup to the opening of the first cup.

21. The exhaust line according to claim 1, wherein the first cup has perforations with a diameter substantially equal to 5 mm or an opening.

22. The exhaust line according to claim 1, wherein the first cup comprises a wire mesh layer over at least part of a surface of the first cup.

23. The exhaust line according to claim 1, wherein the reagent injector is oriented such that an injection direction is perpendicular to the injection portion.

24. The exhaust line according to claim 1, wherein the reagent injector is oriented such that the injection direction is parallel to a tangent to the injection portion.

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